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Towards Measurement of Farm Sustainability – an Irish case study

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Contributed Paper prepared for presentation at the International Association of Agricultural Economists Conference, Beijing, China, August 16-22, 2009

Abstract

Sustainability Indicators (economic, environmental and social) are developed here using Irish National Farm Survey (FADN) data over a ten-year period (1996-2006) in an attempt to measure the sustainability of Irish agriculture at the farm-level. The general concept of sustainability is discussed and the development of agricultural sustainability indicators in an Irish context described. Individual indicators are dealt with in turn and the RERC SMILE model is used to demonstrate how these indicators can be mapped at electoral division level.[1] Economic viability was found to be generally in decline over the ten-year period examined, however, when individual farming systems were taken into account, some were found to perform better than others. Unsurprisingly the more intensive farming systems (primarily dairy) were found to pollute more on average. Irish agriculture is experiencing a period of fundamental change, not least in terms of the ever-changing rural demographic; the challenge therefore lies in ensuring that farms remain economically, environmentally and socially sustainable in the long-term.

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[1] The RERC Spatial Micro simulation model for the Irish Local Economy (SMILE) builds a synthetic dataset of the Irish farm population by statistically matching the National Farm Survey (NFS) and the Census of Irish Agriculture.

1. Introduction

The principle of sustainability is firmly enshrined in the objectives of the Common Agricultural Policy and is one of the forefront issues in European agriculture, indeed much policy reform states sustainability as its goal. The fact remains however, that as a tangible and identifiable goal the concept eludes us (Fricker, 1998:367). The notion has many dimensions, and, deliberation on such has further highlighted its complexity. A widely adopted definition is included in the 1987 report of the World Commission on Environment and Development *"Our Common Future"* (the Brundtland report) which defined it as *"development which meets the needs of the present without compromising the ability of future generations to meet their own needs."* However, almost as well known as this generally accepted definition is the fact that there is no consensus on its precise or operational meaning; its meaning differs across space and time and between individuals (Rigby et al. 2001:464).

Sustainable agriculture is defined as a practise that meets current and long-term needs for food, fibre, and other related needs of society while maximizing net benefits through the conservation of resources to maintain other ecosystem services and functions, and long-term human development. To date there has been relatively little research on agricultural sustainability in an Irish context. This research aims to fill this gap in the literature; developing indicators of economic, environmental and social farm sustainability in Ireland using Irish National Farm Survey data (NFS). In attempting to measure sustainability multidimensional aspects - economic, environmental and social - must be taken into account, however, this can prove difficult in practice at the farm level. Nonetheless, a meaningful measure is required if it is to guide policy.

Section 2 of this paper will introduce the concept of sustainability and the measurement problems associated with it. The issue of composite indicators are also briefly addressed. Section 3 outlines the methodological framework of the research and a description of the data used. Farm-level sustainability indicators are then outlined in section 4. Finally, a discussion of results and an overall conclusion are then contained in sections 5 and 6 respectively.

2. Sustainability

Sustainability is the main principle of the declaration of the Rio Earth Summit and Agenda 21, established in 1992 at the United Nations Conference for Environment and Development (UNCED). The widespread 'adoption' or pursuit of sustainable development, and indicators of sustainability, took off following the summit (Woodhouse et al., 2000:12); triggering wide scientific and policy interest as it brought the three dimensions of development: economic, environmental and social, into an integrated framework (Rao and Rogers, 2006:439). It established a mandate for the UN to formulate a set of indicators that would help gauge progress towards sustainability and there has been a concerted effort since then to construct indicators to monitor progress towards sustainable development. This has included indicators of sustainable land management, land quality indicators and indicators of sustainable agriculture (Rigby et al, 2001:463).

Sustainable development at sectoral (i.e., agriculture) and territorial (i.e., rural area) level represent a priority objective of European Union strategy, as can be derived from many of the most recent documents where one finds that *"all policies…must have sustainable development as their core concern"* (Commission of the European communities, 2001), and that *"sustainable development is a priority at all levels of public governance, and increasing awareness in the private sector"* (Commission of the European Communities, 2002). With regard to the achievement of sustainable agriculture, the basic long-term challenge as seen by the OECD is to produce sufficient food and industrial crops efficiently, profitably and safely, to meet a growing world demand without degrading natural resources and the environment (OECD, 2004).

Indicators of sustainability are designed here in an attempt to measure the economic, environmental and social sustainability of Irish agriculture; these are categorised as such because sustainability is multifaceted in nature and such constructs serve as a useful aid for policy makers. Such an approach seems to have grown out of recognition that sustainability cannot be condensed to a single simple definition (Pannell and Glen, 2000:135).

2.1 Towards a composite indicator?

The characteristics and the complexity of sustainability (multidimensional, global, dynamic) as well as the fact that it reaches out into the future, make it a concept, which gives a certain direction for policy making rather than serving as a benchmark that could be precisely defined. Whereas it seems difficult to identify a quantifiable distance of a certain state to quantified sustainability targets, sustainability indicators should allow one to judge whether a certain development contributes to movement in 'the right direction'. It may be that individual indicators point in two different directions. As it can be difficult to interpret a large set of indicators it is therefore useful to aggregate this multidimensional set of indicators into a single index or composite indicator (Goméz, 2007:3).[2] Composite indicators are becoming increasingly popular for sustainability assessments. They can be more straightforward when interpreting data than trying to find a common trend in separate indicators. However, there is some debate in the literature as to their usefulness; they are helpful in that they can summarise complex or multi-dimensional issues and are easy to interpret, but, they may lack accuracy if poorly constructed. In our analysis the amalgamation of indicators into one composite indicator proved not very useful and they are not dealt with in detail here. The economic and environmental results were highly negatively correlated and in effect cancelled each other out; meaning that the social indicators were the main drivers of the composite indicator.

[2] This should be done with care as there may some subjectivity involved in the design of a composite indicator. The aggregation of indicators has been frequently criticised for: a) the subjectivity of these methods (the choice of functional forms for aggregation and weighting for individual indicators), and b) the compensability usually considered to aggregate the different dimensions or attributes of sustainability (additive aggregation approaches), in spite of their theoretical incommensurability (Goméz, 2007:3).

3. Methodological framework

Indicators encompassing all three dimensions of Irish agricultural sustainability are designed and outlined in this section. Results are then discussed for each of the three in turn.

3.1 Data description

Data used is that of the Irish National Farm Survey (1996-2006), which is collected as part of the FADN dataset. It is a random sample of 1,200 farms representing approximately 115,000 farms nationally.[3] The method of classifying farms into farming systems used in the NFS is based on the EU FADN typology set out in the Commission Decision 78/463. Within the NFS, the farm system variable is broken down into six different categories as follows: Dairying, Dairying and Other, Cattle rearing, Cattle Other, Mainly Sheep and Tillage Systems (Connolly et al., 2005).[4] Indicators (covering the three dimensions of sustainability) are calculated here for different farm-types and future policy scenarios; giving a benchmark measure of agricultural sustainability in the country.

4. Sustainability Indicators

Economic, Environmental and Social indicators of sustainability are developed here to present a benchmark measure of the current sustainability of Irish farming. Indicators were chosen according to their overall suitability and the availability of data in the NFS.

In terms of the economic indicators chosen, the viability of farms is important in order to ascertain which systems are doing well. The Agri-Vision 2015 report concluded that the number of economically viable farm businesses is in decline and that a large number of farm households are sustainable only because of the presence of off-farm income (Hennessy & O'Brien 2006:11). As we do not have information from the NFS on actual off-farm income we cannot examine the extent to which non-farm income plays a role, however, we can assess whether or not, on average, farms across systems are economically viable alone or not. The role of direct payments as a percentage of gross output is also of relevance here.[5] It is interesting to examine the true contribution of payments, given their significance for certain systems in particular. Some worthy

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[3] The weights used to make the NFS representative of the Irish farming population are based on the sample number of farms and the population number of farms (from the Census of Agriculture) in each farm system and farm size category. The sample number of observations by size/system is simply divided by the population number of observations by size/system to get the weights that make the sample representative of the actual farming population.

[4] It should be noted that the system titles in the NFS refer to the dominant enterprise in each group and another enterprise could be present on the farm also.

[5] It makes more sense to examine direct payments as a proportion of gross output rather than FFI. The main components of farm Gross Output (GO) are (i) sales of animals/animal products and crops and (ii) all non-capital subsidies, direct payments, premia and grants (DPs). FFI in the NFS is calculated by deducting all farm costs (direct and overhead) form the value of farm gross output as defined above. DPs therefore contribute to farm output rather than income (which is a residual of output and costs) and annual changes in the magnitude of Direct Payments should be expressed as a percentage of farm gross output and not farm income (Connolly, 2007:9).

questions are raised regarding the post-decoupling era and what the future holds for particular sections of Irish farming with the potential phasing out of payments in the long run. Finally, linked to this is market return, a good indicator highlighting the contribution of direct payments to family farm income across systems.

In terms of environmental indicators chosen, methane emissions are the most important pollutant arising from Irish agriculture and can therefore be thought of as a valuable indicator of environmental sustainability. Also organic nitrogen and phosphorous are particularly important in an Irish context and so are worthy of examination here.

Undoubtedly, the task of choosing the most relevant indicators of social sustainability using variables available in the NFS proved most difficult. Both indicators chosen here are demographic based; the number of household members under the age of 45 and the number of one-person households. Some conclusions with regard to the future social sustainability of Irish farms can be drawn in attempting to approximate the likelihood of succession and the risk of isolation faced by some.

Indicators of sustainability are dealt with in turn in the following sections and some conclusions drawn.

4.1 Economic Indicators

The economic sustainability of Irish agriculture over the past decade is evaluated here by developing a number of economic indicators. These are outlined in the following sections.

4.1.2 Viability

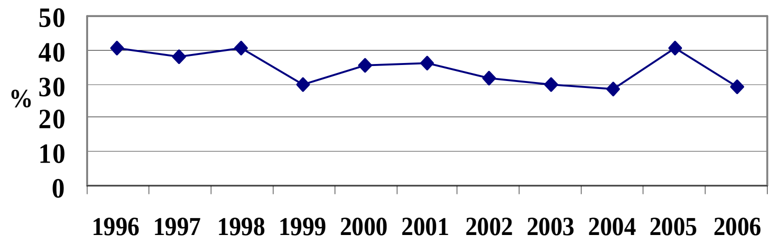
Although the aggregate number of farms in Ireland has declined over the past decade or so, (in line with the trend in all European countries), from 150,000 in 1996 to 133,000 in 2005 (Dept. of Agriculture, Fisheries and Food, 2007), and family farm income (FFI) has also grown, the number of 'viable' farms has in fact been in decline.[6] Based on the work of Hennessy (2004) and Frawley and Commins (1996), an economically viable farm is defined as having (a) the capacity to remunerate family labour at the average agricultural wage,[7] and (b) the capacity to provide an additional 5 per cent return on non-land assets.

The number of viable farms (on average), across all systems between 1996 and 2006 are shown in fig. 2 below. A poor degree of viability is reported upon in general with between 28 and 41 percent of farms only, being classified as economically viable over the ten-year period.

[6] In terms of farm numbers, there were 228,000 farms in Ireland in 1975 and 171,000 in 1991. With regard to FFI, this grew from €13,866 on average per farm in 1996 to €16,680 in 2006. It should be noted however that FFI is inclusive of direct payments and this is having an impact here. This point is developed further in the next section.

[7] In the absence of an average Irish agricultural wage, the minimum wage for agricultural workers as set by the Labour Court annually is used here.

Fig. 2: Viable farms 1996-2006



Source: NFS data

There were no major fluctuations in viability across the years; however there was a larger than normal 10% drop (to 30%) in 1999: this can be explained by the fodder crisis of 1998 and the subsequent reduction in cattle output and family farm income of 17.9 percent the following year (mainly due to higher feed costs, lower cattle prices and reduced direct payments).[8] On the other hand, the large increase in viability in 2005 can be explained by the injection of the once-off payment of the single farm payment received by all farmers in that year.

Apart from these two extremes however, there were no major fluctuations in the economic viability of farms over the decade, with a steady decline from 2001 (apart from the already explained artificial fluctuation in 2005, with 2006 showing a more 'normal' level of viability with only 29% of farms deemed viable). Interestingly, the percentage of viable farms in 2006 was the second lowest year recorded over the ten year period.
Taking each system into account individually over the period (1996-2006) proves somewhat more interesting (see fig. 3 below). In general, variation in farm performance and viability over the years can to some degree be explained by exogenous factors such as a change in the weather, in input costs or market prices. For example, one can again see the impact of the fodder crisis in 1999 across all systems except tillage. On the whole, it can be seen throughout the period that the dairying and tillage systems tend to have a relatively higher proportion of viable farms compared to other systems. Generally speaking it can be seen that the cattle systems appear less viable than all others throughout the decade.[9]

Dealing with each system in turn, 71% of tillage farms were regarded as viable in 1996; ten years later this had fallen to 56%. Even though there was a fall in the number of viable tillage farms, on average, over the period, the proportion of viable farms within the system compares very favourably to the cattle and sheep systems; only 14% of cattle rearing farms were deemed viable in both 1996 and 2006 and only 21% of 'cattle other' farms fell into this category at the start of the period, rising to only 22% in 2006. The number of viable sheep farms fell 8% to 27% over the decade. The dairying systems perform relatively better with 59% of farms termed viable in 1996, falling to 58% in

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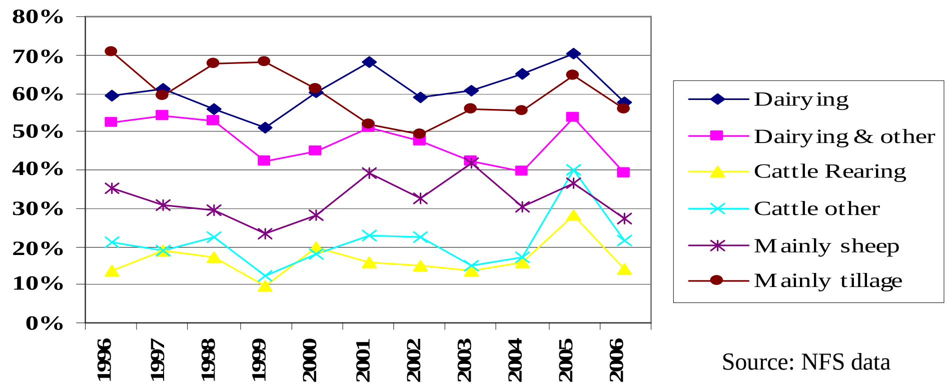
[8] There was a 17.9% decrease in FFI that year due to a decrease in cattle output, a decrease in direct payments and an increase in feed costs due to the fodder crisis of 1998.

[9] It should be noted here that 1996 was a difficult year for the cattle sector, given the BSE crisis and the subsequent impact on cattle prices, which fell by on average 12% (National Farm Survey 1996:1.03).

2006. ‘Dairying and other’ showed a more dramatic decline in viability throughout the decade, with the percentage of viable farms falling from 52% to 32%.

Fig. 3: Average viability by system



Source: NFS data

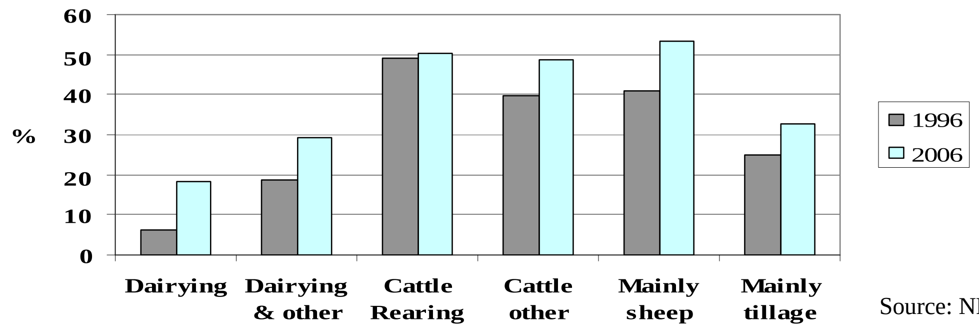
Overall, there is not much fluctuation in viability within systems over the period, however some systems clearly outperform others; the viability of dairy and tillage farmers in particular has more than likely been boosted by higher prices in recent years. The impact of the double payment in 2005 can clearly be seen across systems, distorting the picture somewhat; a clearer indication of the situation can be seen when taking 2006 levels into account with the number of viable farms returning to more ‘normal’ levels.

4.1.3 Importance of Direct Payments

Average Family Farm Income (FFI) in general, grew fairly steadily over the period 1996-2006 to a high of €22,459 in 2005 (an increase of over 30% on the previous year); this large increase was however mainly due to the change in EU policy, implemented in 2005 when the coupled payment system was replaced with a decoupled one. Farmers received on average, a one-off payment of €5,266 per farm due to a carry-over of arrears from 2004 coupled payments (National Farm Surveys 2005, 2006). FFI fell to €16,680 in 2006. As already mentioned FFI includes direct payments received and it is therefore worth examining the role of such payments and their importance in terms of the long term economic viability of Irish farms.[10] The influence of direct payments is illustrated in figure 4 below and such payments as a percentage of gross output are seen to be greater in 2006 than in 1996 for all systems (with the cattle rearing system showing the least amount of change). Such payments are evidently of huge significance to Irish farmers and therefore any future reform should prove important for the future sustainability of Irish farming.

[10] Family Farm Income in the NFS is defined as: Gross output less total net expenses; it represents the total return to the family labour, management and capital investment in the farm business.

Fig. 4: Direct Payments as a % of Gross Output



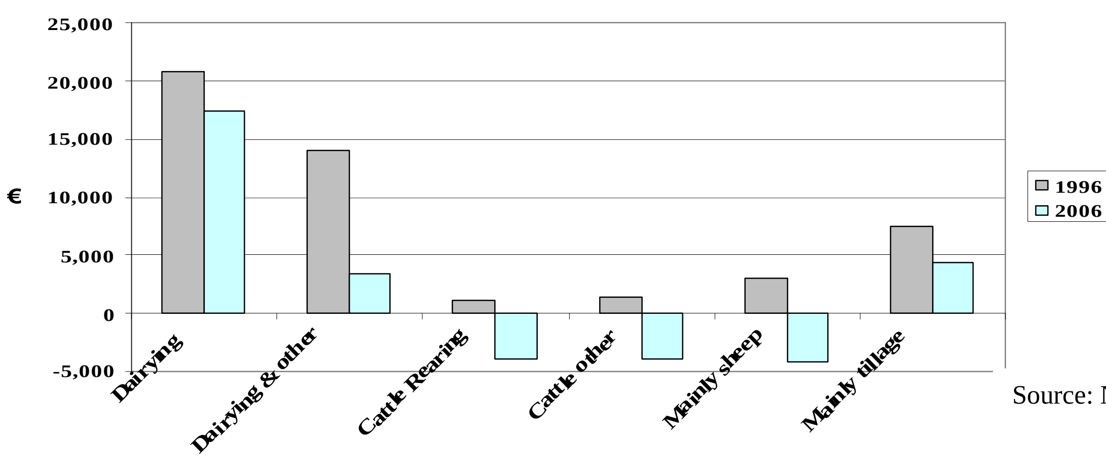
Source: NFS data

The perhaps unexpected increase in direct payments as a percentage of gross output for the dairy systems over the course of the ten-year period can in part be explained by a dairy premium that was introduced in 2004 by way of compensation for intervention price cuts. These payments were based on the individual milk quota produced in that year and in subsequent years and were phased in over three years (and decoupled from production in April 2005). However it should be added here that dairy direct payments are relatively small and the result could be skewed by payments to other enterprises on the farm; i.e., system titles in the NFS refer to the dominant enterprise in each group and therefore some dairy farms would also include direct payments from for example cattle enterprise.

4.1.4 Market Return

Market return per farm is calculated here by subtracting direct payments from family farm income. Only the dairying and tillage systems appear to show a significantly positive market return in both years. All other systems provided some degree of market return in 1996; however, this is seen to diminish over the period, resulting in negative market return in the cattle and sheep sectors in 2006.

Fig. 5: Mkt return by system



Source: NFS data

Interestingly, market return, decreased on average, on farms across all systems, even dairy farms. As market return for cattle and sheep farms on average was found to be negative in 2006 one might question the long-term viability of such farms and suggest that any further trade reform (and subsequent phasing out of payments will impact severely on them).

4.2 Environmental Indicators

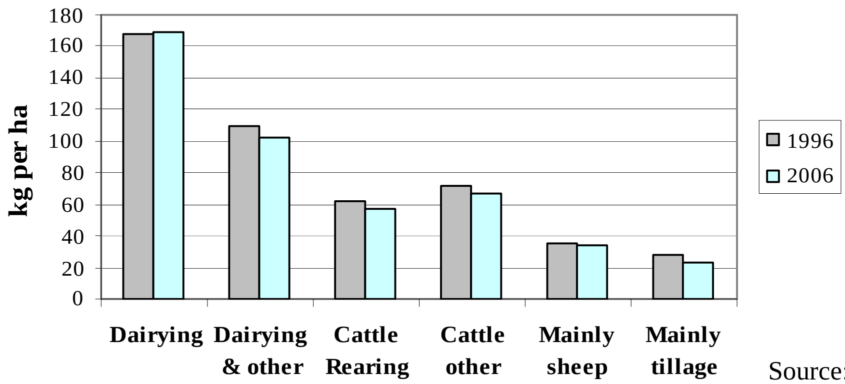
Headline or benchmark environmental indicators can be seen to deal with several different aspects of the environment (soil quality and quantity, water quality, air, habitat diversity and biodiversity). For the purposes of this paper however, it was decided to concentrate on the calculation of indicators concerning air and water quality; computing simple indicators based on variables available in the National Farm Survey. These are outlined in the following section.

4.2.1 Air quality

For the purposes of this study, in terms of the impact of agriculture on air quality, methane emissions are examined here. Methane released through enteric fermentation and manure management in the dairy and beef sectors account for over 50 percent of total greenhouse gas emissions from Irish agriculture (Donnellan and Hanrahan 2003). The monitoring and control of methane emissions from agriculture is therefore important in terms of the overall reduction in greenhouse gas (GHG) emissions in Ireland going forward. According to International Panel on Climate Change (IPCC) reporting procedures and emission factors, GHG emissions from the agricultural sector amounted to 18.96 million tones of carbon-dioxide equivalent, or 27.7% of total recorded GHG emissions from Ireland, in 2004 (Comhar, 2006:147). These were dominated by methane (CH4) which has a global warming potential 21 times that of CO_2, and nitrous oxide (N2O), with a global warming potential 310 times that of CO_2 (IPCC,1995). The goal of reducing emissions poses a major challenge for the agriculture sector. The EU has pledged to reduce GHG emissions by 20% by 2020, and as part of this EU target, Ireland has agreed to limit the growth in GHG emissions to 13% above 1990 levels. However, emissions for 2005 exceeded 1990 levels by 25.4%. The contribution of emissions from agriculture in 2005 was 27.6% which still represents the single largest contribution to our overall emissions (Teagasc, 2008).

Methane emissions (kg per hectare) can be calculated based on livestock emission factors for the different types of livestock recorded in the NFS (see O'Mara *et al.*, 2007). The emission factors represent the quantity of gas produced by an animal over a specific period of time. By multiplying emissions factors for type of animal unit by the size of the herd recorded for each farm in the NFS, the total emissions from a particular source category are generated for each farm. Methane emissions were found to be, as expected, much higher for dairying than for other systems (see fig. 6). Overall, there was very little change across systems throughout the decade, indicating perhaps that going forward there will have to be a more visible reduction across systems.

Fig. 6: Methane emissions, kg per ha

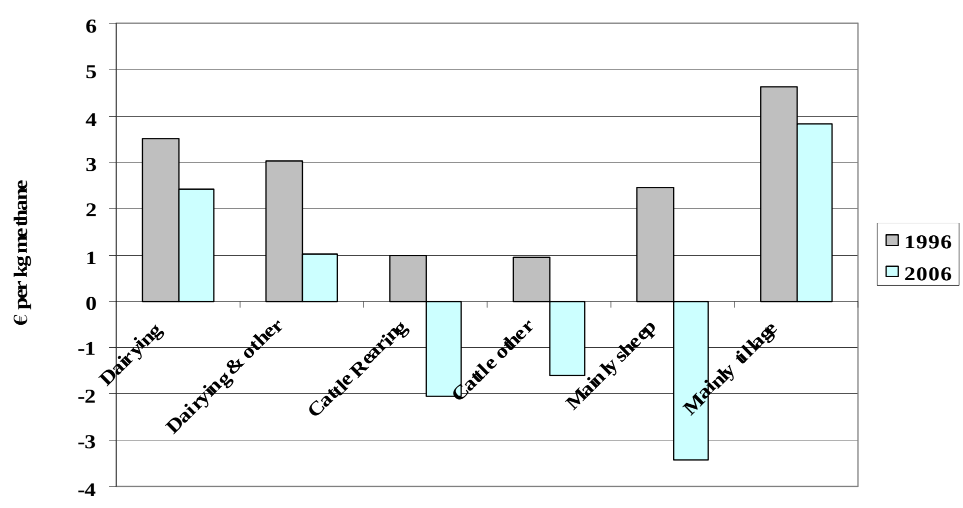


Source: NFS data

Agriculture has a large part to play in reducing national GHG emissions given its current contribution, however instead of forecasting a reduction in livestock numbers; these are in fact expected to rise with the expansion of EU milk quota (Breen, 2008).

Interestingly, upon further investigation it can be seen that higher market return may also be associated with higher methane emissions; with the dairying systems displaying a much higher degree of both, suggesting that more intensive farmers pollute more with higher market return and higher emissions. In calculating market return in terms of methane emissions (€ per kg) only the dairying systems are seen to be making a positive return per kg of methane produced. All other systems are polluting at a loss (see fig.7 below).

Fig. 7: Market Return and Methane Emissions



Source: NFS data

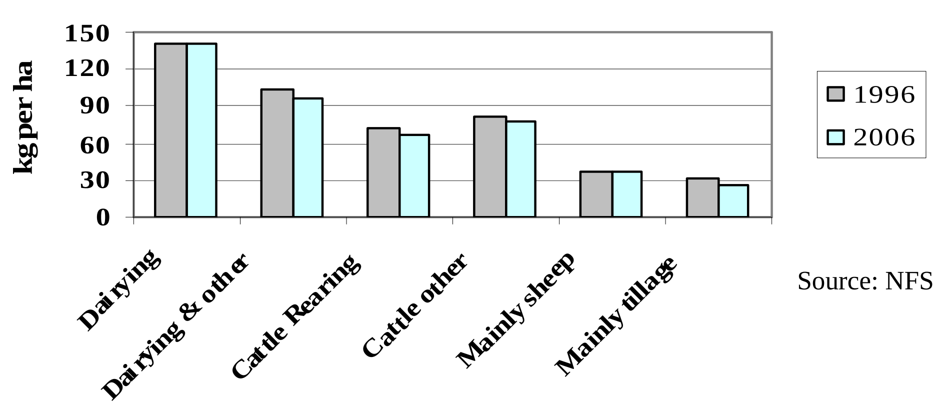
4.2.2 Water Quality

The intensification of agricultural practices, in particular, the growing use of fertilizers and pesticides, and the specialization and concentration of crop and livestock production has had an increasing impact on water quality. The main agricultural water pollutants are nitrates, phosphorus, and pesticides. Rising nitrate concentrations threaten the quality of drinking water, while high pesticide use contributes substantially to indirect emissions of toxic substances. Increasing levels of nitrates and phosphorus in surface waters reduce their ability to support plant and animal life and make them less attractive for recreation (Schierling 1996:32).

Increasing controls over point-source emissions to freshwaters in Ireland (improved sewage treatment and IPPC licensing) have left diffuse agricultural emissions of nitrate (NO_3-) and phosphorus (P) as the dominant contaminants of freshwaters. According to EPA monitoring (EPA, 2004) approximately 30% of river channel length in Ireland is classified as slightly/to moderately polluted, and half of this pollution is attributable to agriculture. Agricultural sources are estimated to account for 70% of the anthropogenic P loading to inland waters, 70-80% of which is estimated to come from diffuse soil losses, while the remaining 20-30% arises from farmyard losses. Phosphorus is the key limiting nutrient for freshwater algal growth, and excessive P losses from soils to water are thought to be responsible for freshwater eutrophication (excessive algal growth which is unsightly and reduces plant and fish diversity) (Comhar, 2006:149). In terms of water quality, both nitrogen and phosphorous are examined for the purposes of this paper.

Organic nitrogen produced on-farm (by livestock) is particularly interesting in an Irish context as agriculture in the country is primarily a pasture-based, livestock-intensive industry. Nitrate leaching is an issue in some areas, particularly on intensively farmed land in the south and east of the country and it poses a major environmental threat. In an effort to alleviate this problem, all Irish farmers must now comply with the legally binding limits of 170kg per hectares organic nitrogen production, set out in the EU Nitrates Directive. Our results indicate that organic nitrogen produced on-farm was seen to change little from 1996 to 2006 (see fig. 9 below). As with methane emissions, the dairying systems show higher levels of pollution than all others over the period.

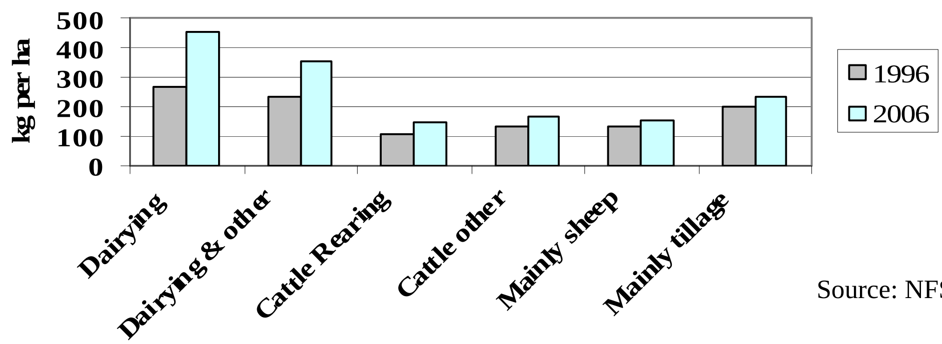
Fig. 9: Organic nitrogen, kg per ha



Source: NFS data

In order to assess overall nitrogen polluting pressure purchased (chemical) nitrogen mineral fertilisers should also be taken into account. Again it can clearly be seen in fig. 10 below that levels of such are generally higher for the dairying systems and have increased relatively more dramatically for these systems over the ten year period.

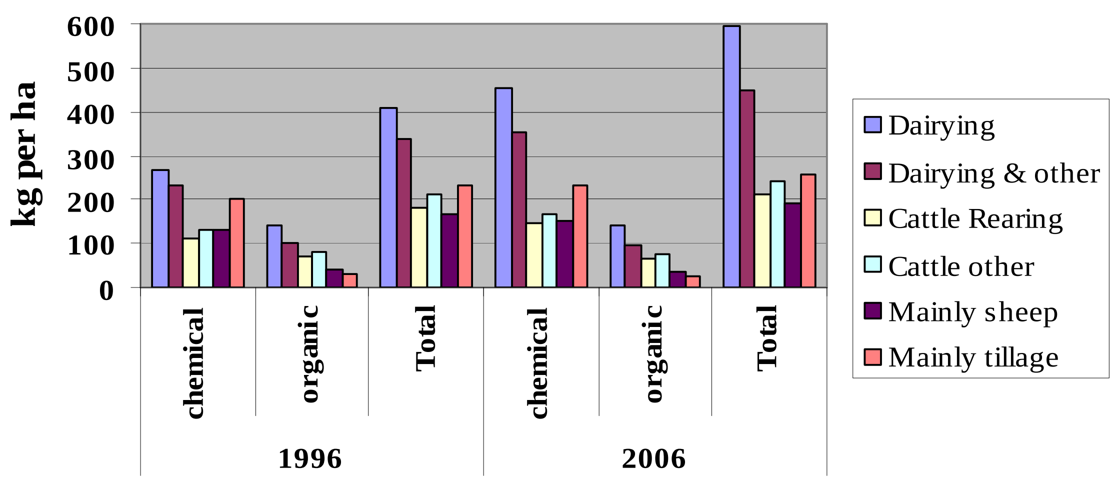
Fig. 10: Chemical Nitrogen, kg per ha



Source: NFS data

Logically then it can be shown that the dairying systems display higher levels of total nitrogen (both organic and chemical) over the period, this can be seen in fig. 11 below with total nitrogen (kg per ha.) higher for the dairying systems than all others in both years. The tillage sector also displays relatively high levels of chemical nitrogen over the period. In general, we see that levels have increased over the period, the increase mainly coming from the increased use of chemical nitrogen.

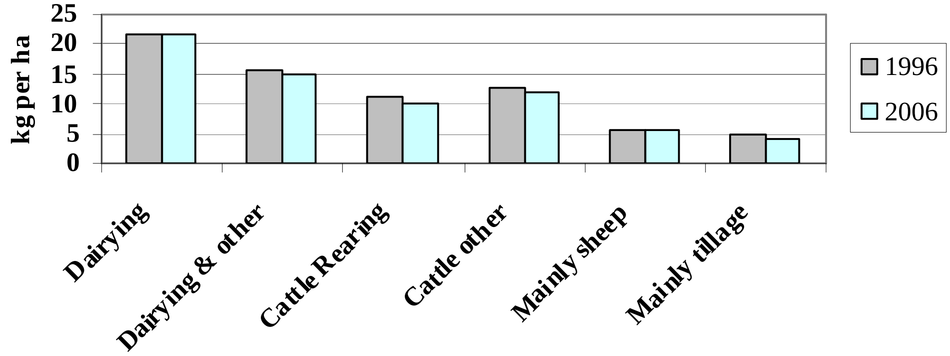
Fig. 11: Total nitrogen, 1996 and 2006



Source: NFS data

As with organic nitrogen, organic phosphorus produced remained fairly static throughout the decade (see fig.12 below). Again it can be clearly seen that the dairying systems display relatively higher levels than other systems.

Fig. 12: Organic Phosphorus, kg per ha



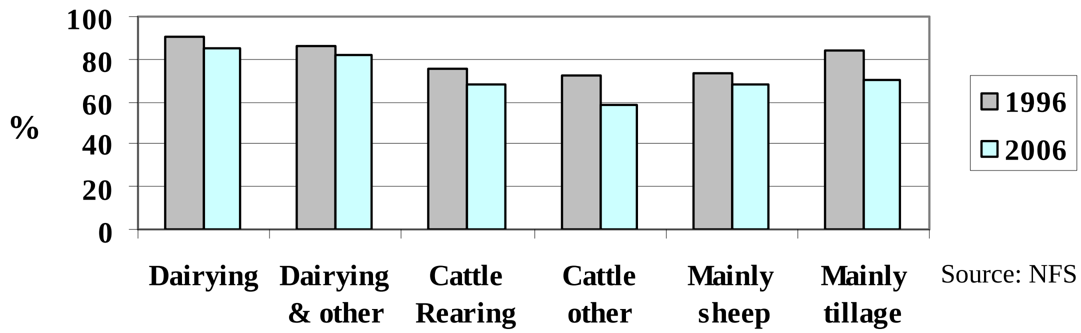
4.3 Social Indicators

Social indicators are statistics which aim to provide empirical, valid measurements of different dimensions of human well-being (Nolan 2003). In the pursuit of agricultural sustainability, economic and environmental factors often take precedent over human well-being, and fail to benefit the social quality of life. Even when taken into account, income was commonly used as an indicator of social welfare, however, there is a growing awareness that concentrating solely on income levels fails to capture the multidimensionality of social welfare and a more broadly based approach that encompasses a whole range of living conditions is necessary. As a result there has been a considerable amount of work in the development of social indicators that measure ‘social cohesion’ as opposed to just drawing a poverty line and examining those who fall below it (Layte et al. 2001, Scott et al. 1996, Whelan et al. 2007). A number of relevant indicators are dealt with below. The calculation of social indicators proved difficult using NFS data (due to a lack of relevant variables), however, it was certainly the best data source available overall and the indicators chosen (although dictated by data availability) prove insightful in evaluating overall agricultural sustainability in an Irish context.

4.3.1 Demographic viability

Anecdotally, one hears of an aging Irish farming population with younger people generally choosing not to join the industry. In order to evaluate how big a problem this actually is, demographic viability is examined here. Taking into account the percentage of farm households which have at least one household member below 45 years of age (i.e., those defined as demographically viable), a slight decline is found over the ten-year period examined here, across all systems (see fig. 13 below). This indicator can perhaps be thought of as an indicator of succession (with the likelihood of someone taking over the farm worsening slightly over the period). An outstanding issue which may be of importance here too is that although the potential successor may currently live away from home (e.g., attending college) they could well intend to return to the farm at some future point. As such individuals are not included in the data the true presence of a successor may be underestimated here.

Fig.13: Demographic viability

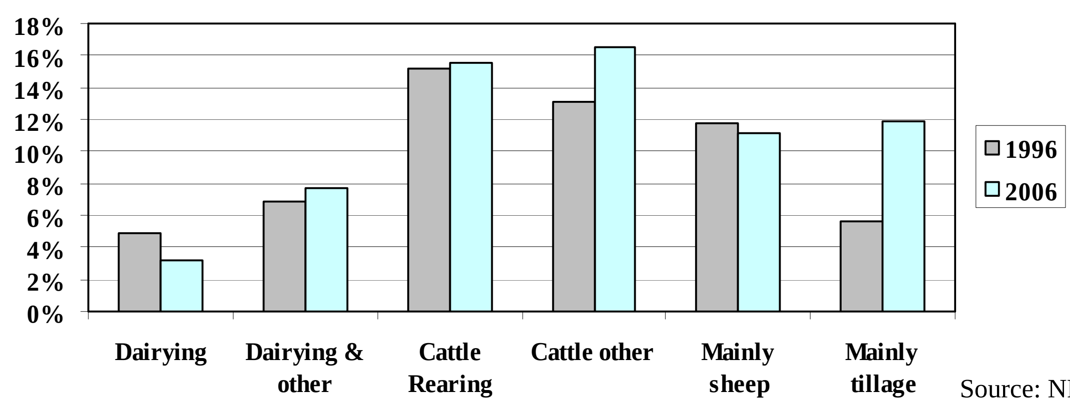


Source: NFS data

4.3.2 Isolation

Results from EU-SILC 2003,[11] indicate that persons living alone (i.e. in single adult households) were most at risk of poverty with almost 45% below the 60% threshold (CSO, 2004). Those living alone in Irish farm households are also thought to be in danger of isolation, with many such people being elderly. Once again using the NFS, Fig. 14 below shows that there was relatively little change in this indicator over the period 1996-2006; however it was seen to fall slightly for dairy and sheep farms and to rise significantly for cattle and tillage farms. Interestingly, the number of dairy farmers living alone tended to be smaller than for other systems.

Fig. 14: Isolation (living alone)



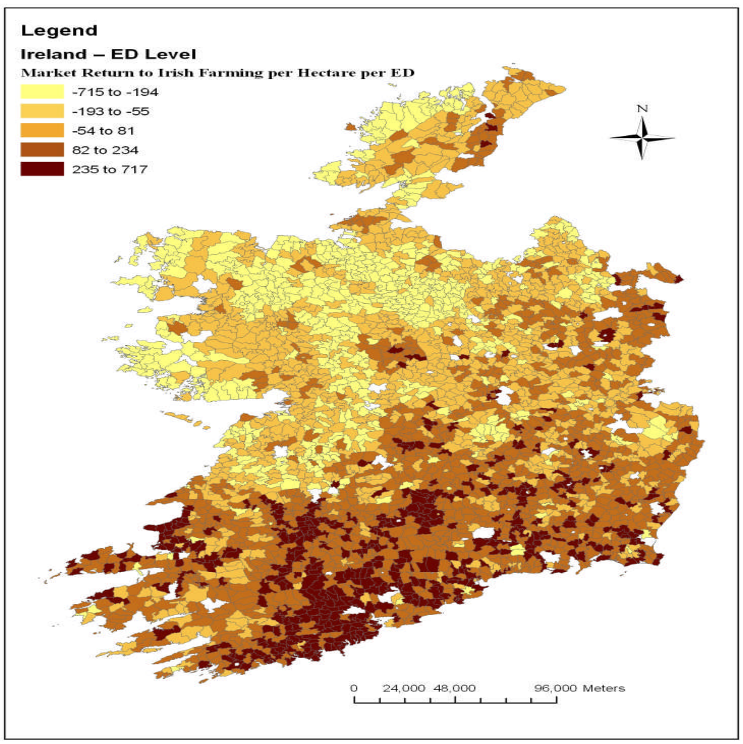
Source: NFS data

[11] EU-SILC dataset – The EU Survey on Income and Living Conditions is conducted by the Central Statistics Office, annually. It is an instrument aiming at collecting timely and comparable cross-sectional and longitudinal multidimensional micro data on income, poverty, social exclusion and living conditions across EU Member states.

4.4 Mapping the indicators using the SMILE model

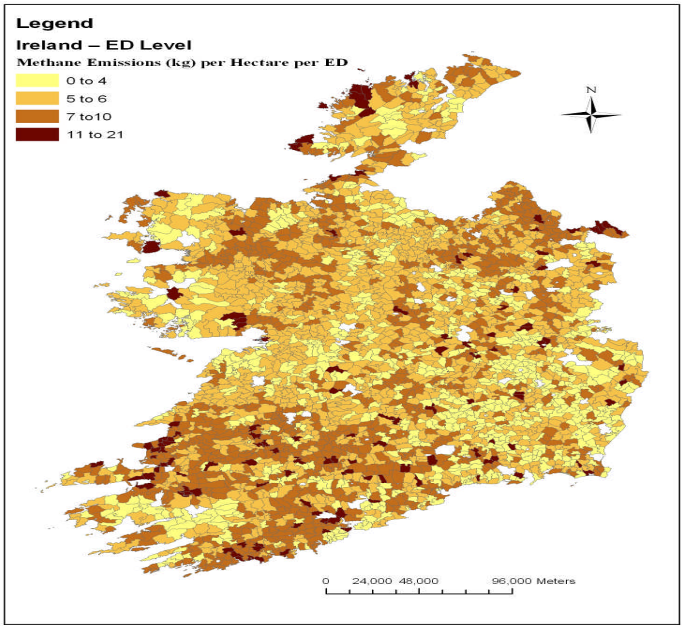
A spatial micro-simulation model, the Simulated Model for the Irish Local Economy (SMILE) is also utilised to produce a synthetic farm population representative by size, system and soil type at Electoral Division (ED) level. A technique called simulated annealing is used to match Census of Agriculture data to the NFS. Indicators are then presented using GIS (Geographical Information System) mapping techniques.[12] A number of examples are outlined below.

Market return (per hectare) and methane emissions (kg per hectare) for each ED are displayed. The lighter areas in map (a) represent low levels of market return; these are generally found in the west and midlands. On the other hand, the darker areas represent those EDs with relatively higher levels of market return (generally found in the south and south east). In map (b) the beige areas are representative of those EDs with relatively low levels of methane pollution whereas the darker areas represent higher levels of pollution. Interestingly but perhaps unsurprisingly, a correlation is found between those EDs with higher market returns and higher emissions.



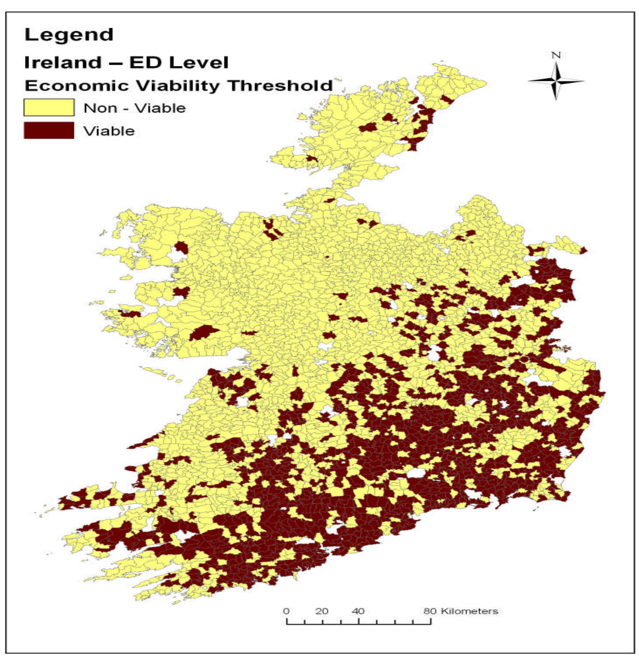
Map A: Market Return per hectare

[12] The SMILE model is an object-orientated spatial micro-simulation model developed by the Rural Economy Research Centre, Teagasc, which aims to simulate statically the population of Ireland.



Map B: Methane Emissions per hectare

The economic viability of Irish farms at the ED level is illustrated in map C below. As detailed above an economic viability threshold is calculated and those farms with a family farm income falling above or below this are deemed viable or unviable respectively. It can be seen that the more economically viable farms are located towards the south of the country where the more intensive farms are situated (brown colour). This is reflective of the long recognised divide above and below the Limerick to Dundalk diagonal with those farms lying below this generally performing better than those above.



Map C: Economic Viability per farm

5. Discussion of results

This section will attempt to evaluate the three dimensions of sustainability, drawing all elements together in an attempt to assess overall agricultural sustainability in Ireland.

Examining viability over the period across systems gives a good insight into the current and future economic sustainability of Irish agriculture. A poor degree of viability is reported upon in general with between 29 and 41 percent of farms only, being classified as economically viable over the ten-year period.[13] Interestingly, the percentage of viable farms in 2006 was the second lowest recorded overall. In looking at particular systems individually it can be seen from the analysis that some systems performed consistently better than others throughout the period; with the dairying and tillage systems tending to have a relatively higher proportion of viable farms compared to other systems. Generally speaking it can be seen that the cattle systems appear less viable than all others throughout the decade.

In attempting to assess the long-run economic sustainability of agriculture the contribution of direct payments cannot go unexamined. In comparing levels of direct payments for 1996 and 2006 one finds that direct payments as a percentage of gross output are seen to be greater in 2006 than in 1996 for all systems. Given the apparent significance of such payments for Irish farmers one would wonder about the implications of any future policy reform on the long-term sustainability of Irish agriculture. To this effect, some systems must be seen as more vulnerable than others with direct payments as a percentage of gross output ranging from 18% for specialist dairy farms, 33% for tillage farms and 53% for sheep farmers.[14] In addition, when direct payments are subtracted from family farm income the true market return from farming remains; here it appears that only the dairying and tillage systems show a significantly positive market return in both years. All other systems provided some degree of market return in 1996; however, this is seen to diminish over the period, resulting in negative market return in the cattle and sheep sectors in 2006. The long-term sustainability of such farms must surely be brought into question, particularly in the event of the phasing out of payments in the long-run.

In terms of examining the environmental aspect of Irish agriculture, a reduction in the level of methane emissions from the sector is important if Ireland is to honour its commitments with regard to the EU goal of reducing GHG emissions by 20% by 2020. When looking at methane emissions from the individual systems, levels from dairy farms were much higher than for others, with little change throughout the decade across systems. In order to reach the aforementioned EU target, reductions will have to be made across systems, particularly dairy.

Finally in terms of the social dimension, it should be mentioned here that the NFS dataset, although the best available for examining the issue of agricultural sustainability

[13] 41% of farms were deemed viable in 2005 however this is artificially inflated with the single farm payment in that year. A more 'normal' level of viability was recorded in 2006 with only 29% of farms categorised viable.

[14] The corresponding figures for the dairying and other system was 29%, for cattle rearing 50% and cattle other 48%.

across the years, was particularly limited with regard to the design of social indicators. In any case the best possible variables were chosen and indicators of demographic viability and isolation calculated. In terms of drawing conclusions from this analysis, there was very little change in demographic viability across systems, with only a slight decline in the number of households with at least one household member below 45 years of age. Similarly when looking at those living alone there was relatively little change in this indicator over the period with an increase in the percentage of dairy and other, cattle, cattle other and tillage farmers living alone and a slight fall in the proportion living alone in the dairy and sheep systems.

6. Conclusion

The sustainability of agriculture is without doubt an emerging area, and one of great interest going forward. This research develops a number of farm level measures of sustainability in an Irish context using NFS data and while this research attempts to provide policymakers with some insight into the current sustainability of Irish farming, the results also highlight the complexity of the concept of farm sustainability and the difficulty of providing a comprehensive measure. It is important to measure sustainability if we are to test the effectiveness of policies however much confusion remains about how best to do so. Having developed sustainability indicators at the farm level using historical data, we are currently in the process of assessing future trends in sustainability, taking a number of policy scenarios into account, it is hoped that some preliminary results will be presented at the conference.

Acknowledgements: This Research is kindly funded by the Department of Agriculture and Food Research Stimulus Fund.

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